Physics 116A Notes
Fall 2004

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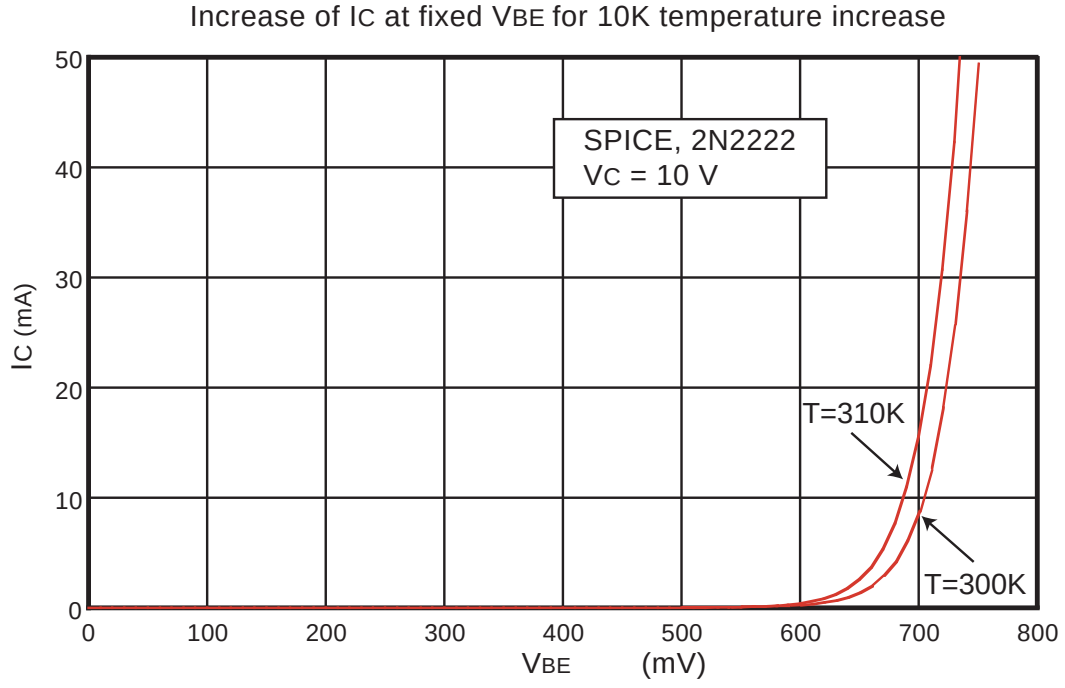
Preliminary Draft v.0.8

- References:
  - Text for course:
    Fundamentals of Electrical Engineering, second edition, by Leonard S. Bobrow, published by Oxford University Press (1996)
  - Others as noted

BJT Temperature Dependence and Bias Stability

- SPICE analysis, $V_{CE} = 10$ V, emitter grounded, T = 300 K and T = 310 K

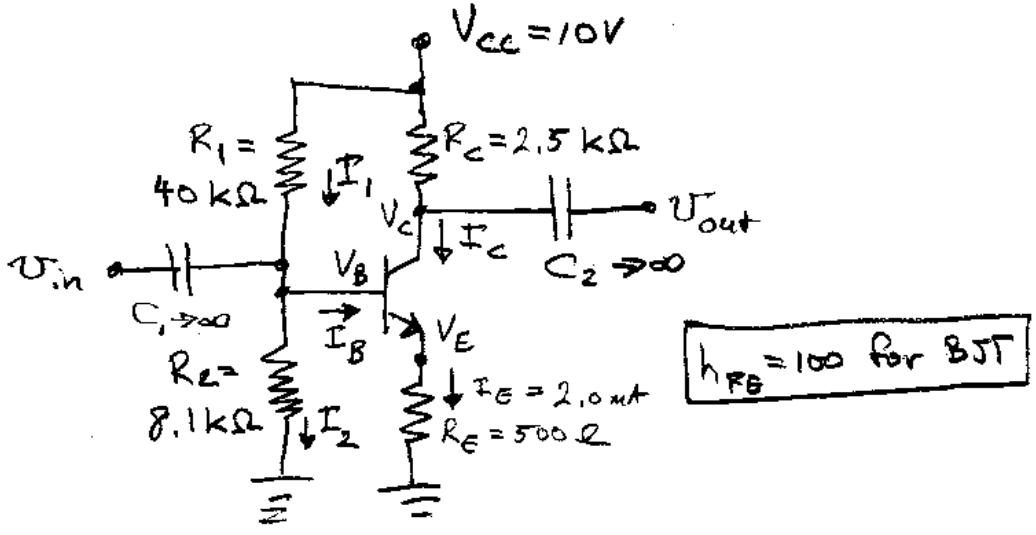


- In active region, I_C increases significantly for 10 K temperature increase (I_E does the same)

Emitter Resistor Gives Bias Stability

- Due to the voltage drop across R_E, an increase in I_E causes a reduction in V_{BE} (since V_B is approximately constant)

- This negative feedback yields a stable operating point despite variations in temperature, etc.



- For example, if T increases, I_E increases for fixed V_{BE}

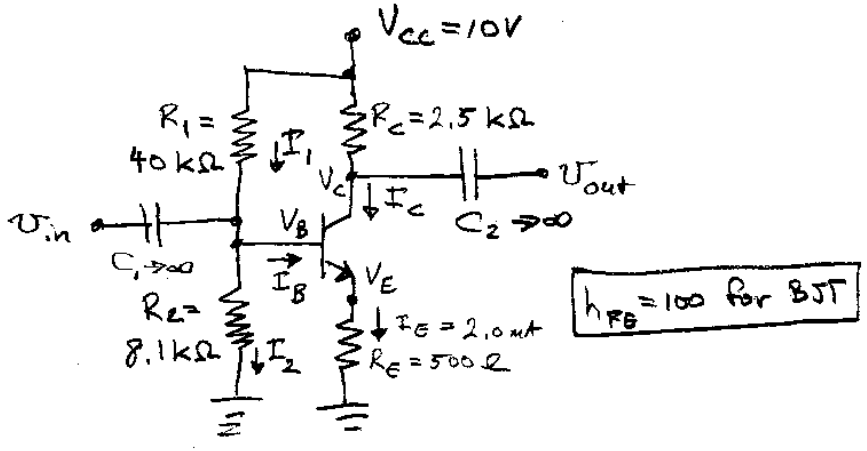
- But the increased I_E increases the voltage drop across R_E, raising V_E and reducing V_{BE} : this brings I_E back toward the design value

Comment on Negative Feedback and Gain

- The negative feedback also reduces the amplifier gain
- The AC gain can be recovered by bypassing R_E with a large C_E in parallel with R_E
- In this way one can bias stability and high gain
- This was shown in the last slide of the previous set of notes

Bias Stability with R_E: SPICE Example

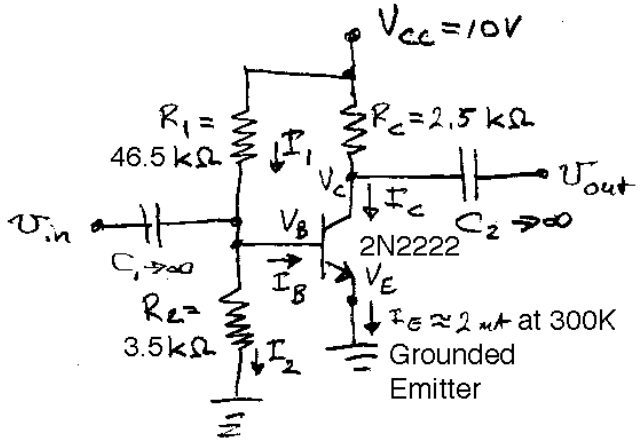
- Our initial estimate assumed $I_{E_Q} = 2$ mA and $h_{FE} = 100$. We calculated $V_{E_Q} = 1$V, $V_{B_Q} = 1.7$V and $V_{C_Q} = 5$V



- Simulate using SPICE and a 2N2222 BJT at T=300 K and T=310 K
- At T=300 K, $I_{E_Q} = 1.89$ mA, $V_{E_Q} = 0.95$V, $V_{B_Q} = 1.61$V and $V_{C_Q} = 5.3$V (reasonable agreement with our estimate–within 6%)
- At T=310 K, $I_{E_Q} = 1.93$ mA, $V_{E_Q} = 0.97$V, $V_{B_Q} = 1.61$V and $V_{C_Q} = 5.2$V
- Q point is reasonably stable

SPICE Example without R_E

- Now eliminate R_E and choose new values for $R_1 = 46.5$ KΩ and $R_2 = 3.5$ KΩ to give $I_{E_Q} \approx 2$ mA at T=300K (using SPICE and a 2N2222 BJT)



- At T=300 K, $I_{E_Q} = 2.1$ mA, $V_{E_Q} = 0$V, $V_{B_Q} = 0.66$V and $V_{C_Q} = 5.1$V
- At T=310 K, $I_{E_Q} = 2.8$ mA, $V_{E_Q} = 0$V, $V_{B_Q} = .65$V and $V_{C_Q} = 3.6$V
- At T=320 K, $I_{E_Q} = 3.5$ mA, $V_{E_Q} = 0$V, $V_{B_Q} = .64$V and $V_{C_Q} = 1.9$V
- **Q point is not stable.** As T increases, I_{E_Q} increases and V_{C_Q} falls significantly. The BJT tends toward saturation with increasing T.